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ANALYSIS OF SEASONAL VARIATIONS IN AIR POLLUTANT LEVELS

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Elbert C. Tabor and Donald H. Fair
National Air Sampling Network
Laboratory of Engineering and Physical Sciences
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16. Abstracts The results of a study of the seasonal variations in air pollutant levels and the various factors that may be responsible for these variations are presented. Data was collected for three years from 48 continental urban stations and 39 continental nonurban stations. No great differences are observed when seasonal variations of suspended particulate concentrations are compared on a regional basis.

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ANALYSIS OF SEASONAL VARIATIONS IN AIR POLLUTANT LEVELS

Elbert C. Tabor and Donald H. Fair
National Air Sampling Network
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Previous papers based on data obtained by the National Air Sampling Network have been presented for the purpose of reporting concentrations of particulate pollutants (1) and the relationship between the levels of benzene soluble organic matter and particulate matter in the air (2) over a large number of American communities, both urban and nonurban. This paper presents the results of a study of the seasonal variations in air pollutant levels and the various factors that may be responsible for these variations.

The year was divided into four seasons of 3 months each based on meteorological data, rather than into the traditional astronomical seasons. The summer season is defined as the warmest quarter, winter the coldest, spring and fall the intervening quarters. The earliest and latest dates (Table 1) when the seasons normally begin in various sections of the United States are based on data reported by over 600 professional and voluntary weather observers (3). If the average beginning dates for the respective seasons are established as December 1, March 1, June 1, and September 1, in no case will the extreme beginning date differ more than 10 days from those given in Table 1.

This paper is based on 3 years (1957-1959) of data from each of 48 continental urban stations and/or one to three years of data from each of 39 continental nonurban stations. The data used had to meet certain previously established criteria (1), e.g., each year had to be represented by 20-26 samples distributed fairly uniformly throughout the entire year. The geographical distribution and regional groupings of the stations are shown in Figure 1. The urban distribution was adequate, ranging from four stations in Regions II and III to seven in Region VI. The nonurban distribution was not so uniform, ranging from two stations in Region II to six in Region I. Data from the extra-continental stations in Alaska, Hawaii, and Puerto Rico were not included, since their seasonal patterns are not directly comparable to those of the mainland. Data from urban stations with less than 3 full years of samples were not included -- it has been found that the quality of the data is considerably improved if more than a single year's results are included. Because of the small amount available all nonurban data were included in the computation of the national and regional seasonal levels.

More directly comparable data are obtained if, instead of the mean seasonal pollutant concentrations, the ratios of the mean seasonal concentration to the mean annual concentration are determined. The relative seasonal concentration was computed for each

station. Computations for three stations are shown in Table 2. In Portland, Oregon, for example, the ratio of the winter mean particulate level (105 $\mu g/m^3$) to the 3-year mean (96 $\mu g/m^3$) is 1.09; for the spring (75 $\mu g/m^3$ to 96 $\mu g/m^3$), 0.78; for the summer (70 $\mu g/m^3$ to 96 $\mu g/m^3$), 0.73; and for the fall (133 $\mu g/m^3$ to 96 $\mu g/m^3$), 1.39.

Seasonal Variations in Suspended Particulate Concentrations.

Relative seasonal concentrations of suspended particulate matter for the nation for the nine regions, and for 48 urban stations are shown in Table 3. The seasonal patterns for the nation and for most regions are presented graphically in Figure 2. No extreme differences in the national seasonal levels can be observed, although high winter level is significantly higher (1.3 times) than the low summer level.

If seasonal variations are compared on a regional basis, no great differences can be observed. (Table 3, Figure 2). With the exception of the Rocky Mountain region, where the lowest concentrations occur in the spring, all regions show the lowest concentrations in summer. Highest levels occur in the winter and/or fall, except in the Great Plains where spring levels are highest. This is probably caused by the contribution of wind-blown dust to the general pollutant levels during the dry spring months.

The greatest variation between seasons is in the mideast, where the high winter level is 1.7 times the low summer level; the smallest variation is in the midwest, where the high winter level is only 1.1 times the low summer level.

Examination of the data for each station shows that the 48 stations can be separated into categories according to the season in which the maximum particulate level occurs. Twenty-three stations have maxima in the winter, ten in the spring, three in the summer, seven in the fall, and five in two seasons. Three stations (Charlotte, Albuquerque, and San Francisco) have highest winter maxima of 1.4 times the 3-year mean, and 2.4, 2.1, and 2.0 times the low seasonal level, and four stations (Atlanta, Indianapolis, Cincinnati, and St. Louis) have low winter maxima of 1.1 times the mean level and 1.3 times the low seasonal level. The spring highs ranged from 1.1 (Nashville) to 1.4 (Bismarck) times the 3-year mean and from 1.3 to 2.4 times the minimum seasonal level. The summer peaks were approximately 1.2 times the 3-year mean and from 1.5 to 1.6 times the seasonal low, whereas the fall maxima ranged from 1.1 to 1.4 times the mean concentration. Except for the fact that approximately one-half of the stations had particulate peaks in the winter and the remainder in other seasons; no other outstanding differences were found between patterns for the four categories. The fact that half the stations show high levels in seasons other than winter indicates that factors other than seasons have a pronounced effect on the concentration of atmospheric pollutants.

No clear-cut relationship between seasonal pollutant levels and geographical location can be demonstrated. Most stations with

winter maxima are concentrated in the southern Rocky Mountain and Pacific Coast areas and east of the Mississippi, whereas stations with highest levels in other seasons are distributed randomly over the entire United States.

In Table 4, seasonal levels for the urban stations are compared according to population. The patterns for population classes 1-6 are practically identical to that for the 48 stations as a group, with maxima in the winter and minima in the summer; classes 7 and 8 show the opposite seasonal picture, with summer maxima and winter minima. The patterns for classes 3-6 probably result from good geographical distribution of the cities within each class; this is not true for classes 1 and 2. Four of the five small cities in population classes 7 and 8 are in either the Great Plains or the Rocky Mountains and therefore, would be subject to the unusual conditions associated with those regions.

The national seasonal pattern for the nonurban stations as a group offers quite a contrast to that for the urban stations (Figure 3). The pattern for the former is the exact opposite of that for the latter, with highest levels in the summer and lowest in the winter. If the seasonal nonurban average particulate levels are subtracted from the corresponding gross urban levels, a net urban seasonal pollutant concentration is obtained. The net urban seasonal level gives a more accurate picture of urban pollution, as it is related to the seasons. The gross urban data show that the high winter level is 1.3 times the low summer level. If the corrected data are used however, the high winter level is 1.8 times the low summer level, indicating that the man-made contribution to urban pollution is considerably greater in winter than the gross urban data alone show.

Considerable differences exist between the regions (Table 5). The Rocky Mountain region shows marked seasonal variations, with a summer peak concentration 4.3 times the winter low. The high summer peak is, no doubt, the result of inclusion of wind-blown dust, which is quite common in the Rocky Mountain and Wasteland areas during the summer months. This same effect would be shown in the Pacific Coast region, which includes two Wasteland stations; however, a single coastal station with an entirely different seasonal pollution pattern compensates for the two Wasteland stations. The least variation occurred in the Southeast, where high spring levels were 1.2 times the summer low and in the Mideast, where the spring and summer levels were 1.3 times those in the fall and winter.

Of the 34 nonurban stations for which at least 2 years of data are available, three have highest particulate concentrations in the winter, ten in the spring, sixteen in the summer, and three in the fall; two show no significant seasonal differences.

An extreme seasonal variation was shown by the Montana station, the mean summer level was 7.7 times the mean winter level. Many other stations exhibited 2.5-fold differences in seasonal levels. The minimum seasonal differences occurred at the Mississippi station (Gulf Coast), where the fall level was 1.1 times the winter and summer levels.

It should be pointed out that although the stations with summer maxima are fairly evenly distributed between the Rocky Mountains and the extreme eastern part of the United States the western stations in general have much higher relative levels than the eastern stations. The higher levels for the western stations can be attributed to the ubiquitous wind-blown dust. The higher levels for the eastern stations are probably related to natural aerosols produced by growing vegetation, since the occurrence of wind-blown dust is not as common in this section of the country. Since distribution of stations in the other categories does not follow any definite pattern, it is difficult to offer a satisfactory explanation for seasonal variations.

If the gross urban mean seasonal particulate concentrations for individual cities are corrected for the background nonurban pollution by use of data from the nearest nonurban station, a variety of results are obtained (Table 6). For many stations the net seasonal patterns are more clearly defined that the gross seasonal patterns (Charleston), and the net seasonal maximum may become greater than the gross (Phoenix, Pittsburgh); for others the net maximum occurred in a different season than the gross (Helena). Thus, it can be seen that a much clearer picture of urban pollution can be obtained if the gross urban levels are corrected for background pollution.

If all the nonurban stations are grouped by topographic class (Atlantic Coast, Great Lakes, Gulf, Pacific, Desert, and Rocky Mountain, Farmland, Forest) and stations in each class compared, considerable differences are evident (Table 7), not only between classes but between stations in the various classes. The patterns for the Desert, Great Lakes, and Mountain classes resemble the National nonurban pattern with peak levels in the summer and low levels in the winter, but with summer levels from 2 to 2.4 times the winter levels, compared to 1.5 for the National nonurban. The patterns for the Atlantic Coast, Farmland, and Forest stations are similar, having highest levels in the spring and lowest levels in fall or winter. Considerable uniformity of seasonal patterns can be observed for the individual stations within each of five topographic classes; all Desert stations, all Mountain stations, and three out of four (fourth in spring) Great Lakes stations had highest levels in the summer, three of four Forest stations had maximum levels in the spring (fourth in summer), and all Gulf Coast stations had peak concentrations in the fall. No similarity can be found between individual stations in the Atlantic Coast and Farmland classes.

On the basis of the data presented above, it appears that for five of the eight nonurban topographic classes there are characteristic seasonal patterns of suspended particulate levels, and with only a few exceptions, all stations within a particular class follow the characteristic seasonal pattern of the class.

SEASONAL VARIATIONS IN LEVELS OF BENZENE SOLUBLE ORGANIC MATTER

Data on the levels of benzene soluble organic matter (Table 8) from the 48 urban stations were treated the same as those of

particulate matter. The seasonal patterns were similar to those for particulate matter; however, the differences between seasons were more clearly defined.

For the nation as a whole the highest concentrations of organic pollutants occurred in the winter (15.3 $\mu g/m^3$), next highest in the fall (11.9 $\mu g/m^3$), next highest in the spring (9.8 $\mu g/m^3$), and lowest in the summer (7.8 $\mu g/m^3$). The high summer level was 1.9 times the summer low. Regionally, the patterns differ only slightly from the National pattern and show considerable uniformity, with the lowest levels occurring in the summer and highest in the winter, except in the Gulf South where highest levels occurred in the winter and fall. The Pacific Coast showed the greatest variation between seasons with a winter level 3 times the summer level, and the Great Plains showed least variation with a winter level 1.4 times the summer level.

Of the 48 urban stations, 36 showed the highest levels of benzene soluble organic matter in the winter, 11 in the fall, and one in the spring. No significance can be attached to this random geographical distribution. Differences between seasonal levels for individual stations were much greater, and more stations showed greater differences than for particulate concentrations. The greatest seasonal difference was shown by Charlotte, where the winter maximum concentration (26.0 $\mu g/m^3$) was 5 times the summer minimum (5.2 $\mu g/m^3$); the smallest difference occurred in Bismarck, where the fall peak (4.5 $\mu g/m^3$) was only 1.2 times the summer low (3.7 $\mu g/m^3$).

If the stations are grouped according to population class, as was done for suspended particulates, and the seasonal patterns compared, the results for organic pollutants are somewhat different than those for the particulates. Although there were minor variations within population classes, the resemblance of the seasonal patterns for the individual classes to the National pattern was striking to say the least -- in all classes the levels for the four seasons followed the same order as the National, i.e. winter > fall > spring > summer. This is quite a contrast to the findings for suspended particulates; the pattern for the smallest population class was the opposite of the National pattern, and the patterns for the other classes differed slightly in many respects from the National pattern.

The more orderly relationships found for the organic fraction may indicate that the concentration of the organic pollutants is a better index of man-made pollution than the concentration of suspended particulates. Wind-blown dust contributes little to the concentration of organic pollutants; in contrast, it is a major influence on the concentration of particulates. On the other hand, natural aerosols arising from vegetation could contribute to the concentration of organic matter, but the total amount contributed would probably be insignificantly small.

SUMMARY AND CONCLUSIONS

1. Urban stations as a group show highest average seasonal pollutant levels in the winter and lowest in the summer, whereas the

nonurban levels are highest in the summer and lowest in the winter. A clearer picture of urban pollution results if gross urban data are corrected for background pollution.

2. The high winter urban levels are no doubt the result of increased fuel usage and/or meteorological factors favorable to high pollutant levels. The nonurban winter pattern can best be explained on the basis of the snow cover or wet weather during the winter months, which results in suppression of wind-blown dust, and also on the basis of the lowered production of natural aerosols in those areas where vegetation is inactive during winter months. The higher summer nonurban particulate concentrations are the result of wind-blown dust in the west and of increased production of natural aerosols by growing vegetation particularly in the eastern section of the United States.

3. No significant differences could be observed between seasonal patterns of urban air pollution for the different population classes. Except for the lowest population class, the patterns for individual classes were very similar to the National pattern.

4. Classification of nonurban stations by topography resulted in many groups of stations having similar seasonal pollution patterns.

5. Concentration of organic pollutants may provide a better index of man-made pollution, since they are not greatly influenced by natural pollution.

6. On the basis of the 3 years of data on which this paper is based, it is not possible to draw general conclusions regarding seasonal patterns of urban particulate pollutant levels. The majority of the stations may fall into the "expected" seasonal pollution pattern, however, a substantial minority do not conform to the traditional pattern. It is possible that a clearer picture can be obtained after several additional years of data have been obtained and analyzed.

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3. Vischer, Stephen S. Climatic Atlas of the United States. Harvard University Press, Cambridge, 1954.

Table 1. SEASON STARTING DATES

Season	Earliest Date	Latest Date	Average Date
Winter	Nov. 25	Dec. 10	Dec. 1
Spring	Feb. 27	Mar. 10	Mar. 1
Summer	May 25	June 10	June 1
Fall	Aug. 25	Sept. 10	Sept. 1

Table 2. COMPUTATION OF RELATIVE SEASONAL POLLUTANT LEVELS.

Station	3-Year Mean Levels ($\mu g/m^3$)					Relative Levels			
	W	Sp	Su	F	Annual	W	Sp	Su	F
Portland, Oreg.	105	75	70	133	96	1.09	0.78	0.73	1.39
Bismarck, N. D.	63	127	97	78	93	0.68	1.37	1.04	0.84
Albuquerque, N. M.	304	153	188	219	212	1.43	0.72	0.89	1.03

Table 3. SEASONAL LEVELS OF SUSPENDED PARTICULATE MATTER

Urban Stations

Station	Region	Mean Levels, µg/m3					Relative Levels			
		Winter	Spring	Summer	Fall	3-Year	Winter	Spring	Summer	Fall
Hartford, Conn.	I	127	106	80	85	100	1.27	1.06	0.80	0.85
New Haven, Conn.	I	119	79	84	89	93	1.28	0.85	0.90	0.96
Boston, Mass.	I	186	153	115	127	143	1.30	1.07	0.80	0.89
Providence, R. I.	I	124	141	95	113	117	1.06	1.21	0.81	0.97
Burlington, Vt.	I	52	64	50	43	53	0.98	1.21	0.94	0.81
Wilmington, Del.	II	232	179	161	145	180	1.29	0.99	0.89	0.81
New York City, N. Y.	II	229	210	187	170	200	1.15	1.05	0.94	0.85
Philadelphia, Pa.	II	215	170	140	205	185	1.16	0.92	0.76	1.11
Pittsburgh, Pa.	II	225	242	219	162	215	1.05	1.13	1.02	0.75
Baltimore, Md.	III	179	157	122	120	144	1.24	1.09	0.85	0.83
Charlotte, N. C.	III	177	117	74	115	122	1.45	1.02	0.61	0.94
Norfolk, Va.	III	140	125	102	93	114	1.23	1.10	0.89	0.82
Charleston, W. Va.	III	243	242	138	231	215	1.13	1.13	0.64	1.07
Birmingham, Ala.	IV	211	157	110	159	161	1.31	0.98	0.68	0.99
Tampa, Fla.	IV	100	100	79	93	93	1.08	1.08	0.85	1.00
Atlanta, Ga.	IV	127	121	114	102	117	1.09	1.03	0.97	0.87
Jackson, Miss.	IV	68	75	102	82	82	0.83	0.91	1.24	1.00
Columbia, S. C.	IV	152	126	100	124	125	1.22	1.01	0.80	0.99
Nashville, Tenn.	IV	158	166	132	154	153	1.03	1.08	0.86	1.01
Indianapolis, Ind.	V	195	169	155	165	171	1.14	0.99	0.91	0.96
Detroit, Mich.	V	158	177	144	140	155	1.02	1.14	0.93	0.90
Cincinnati, Ohio	V	160	129	130	138	140	1.14	0.92	0.93	0.99
Youngstown, Ohio	V	162	163	120	182	159	1.02	1.03	0.75	1.14
Cleveland, Ohio	V	183	190	172	156	176	1.04	1.08	0.98	0.89
Columbus, Ohio	V	163	147	148	173	158	1.03	0.93	0.94	1.09
Milwaukee, Wisc.	V	143	164	145	154	152	0.94	1.08	0.95	1.01
Des Moines, Iowa	VI	198	179	166	140	172	1.15	1.04	0.97	0.81
Minneapolis, Minn.	VI	166	183	77	91	128	1.30	1.43	0.60	0.71
Kansas City, Mo.	VI	176	175	147	161	165	1.07	1.06	0.89	0.98
St. Louis, Mo.	VI	217	185	172	193	192	1.13	0.96	0.90	1.01
Omaha, Neb.	VI	114	134	112	172	134	0.85	1.00	0.84	1.28
Bismarck, N. D.	VI	63	127	97	78	93	0.68	1.37	1.04	0.84
Sioux Falls, S. D.	VI	92	128	80	102	102	0.90	1.25	0.78	1.00
Little Rock, Ark.	VII	80	84	84	90	85	0.94	0.99	0.99	1.06
New Orleans, La.	VII	92	97	74	105	92	1.00	1.05	0.80	1.14
Albuquerque, N. M.	VII	304	153	188	219	212	1.43	0.72	0.89	1.03
Houston, Tex.	VII	119	143	108	120	123	0.97	1.16	0.88	0.98
San Antonio, Tex.	VII	150	156	110	114	133	1.13	1.17	0.83	0.86
Denver, Colo.	VIII	163	105	103	123	125	1.30	0.84	0.82	0.98
Boise, Idaho	VIII	119	97	113	137	117	1.02	0.83	0.97	1.17
Helena, Mont.	VIII	67	64	97	92	81	0.83	0.79	1.20	1.14
Salt Lake City, Utah	VIII	160	97	98	114	116	1.38	0.84	0.84	0.98
Cheyenne, Wyo.	VIII	42	41	65	61	52	0.81	0.79	1.25	1.17
Phoenix, Ariz.	IX	303	203	167	231	228	1.33	0.89	0.73	1.01
Los Angeles, Calif.	IX	246	160	190	234	204	1.21	0.78	0.93	1.15
San Francisco, Calif.	IX	115	66	56	80	80	1.44	0.83	0.70	1.00
San Diego, Calif.	IX	118	74	86	109	98	1.20	0.76	0.88	1.11
Portland, Oreg.	IX	105	75	70	133	96	1.09	0.78	0.73	1.39

Table 3. SEASONAL LEVELS OF SUSPENDED PARTICULATE MATTER (CONTINUED)

Urban Regional and National

Region	Number	Mean Levels, $\mu g/m^3$					Relative Levels			
		Winter	Spring	Summer	Fall	3-Year	Winter	Spring	Summer	Fall
New England	I	122	109	85	91	101	1.18	1.08	0.89	0.90
Mid Atlantic	II	225	200	177	171	195	1.16	1.02	0.90	0.88
Mid East	III	185	160	109	140	149	1.26	1.09	0.75	0.92
South East	IV	136	124	106	119	122	1.09	1.02	0.90	0.98
Mid West	V	166	163	145	158	159	1.05	1.02	0.91	1.00
Great Plains	VI	147	159	122	134	141	1.01	1.16	0.86	0.95
Gulf South	VII	149	127	113	130	129	1.09	1.02	0.88	1.01
Rocky Mountain	VIII	110	81	95	105	98	1.07	0.82	1.02	1.09
Pacific Coast	IX	177	116	114	157	141	1.25	0.81	0.79	1.13
National		157	138	118	134	136	1.15	1.01	0.87	0.99

TABLE 4. SEASONAL LEVELS OF SUSPENDED PARTICULATES

Urban Stations by Population Class

Pop. Class	Population	Number of Stations	3-Year Mean $\mu g/m^3$	Relative Seasonal Levels			
				W	Sp	Su	F
National		48	136	1.15	1.01	0.87	0.99
1 & 2	> 1,000,000	4	186	1.13	0.97	0.89	1.00
3	700,000-1,000,000	6	145	1.13	1.03	0.88	0.95
4	400,000-700,000	13	147	1.16	1.02	0.86	0.96
5	100,000-400,000	16	126	1.16	0.98	0.85	1.01
6	50,000-100,000	4	156	1.14	1.10	0.78	0.97
7 & 8	10,000-50,000	5	79	0.86	1.00	1.08	1.03

Table 5. SEASONAL LEVELS OF SUSPENDED PARTICULATE MATTER

Nonurban Stations

Station	Years Data	Topo. Class	Mean Levels, $\mu g/m^3$ Winter	Spring	Summer	Fall	1-3 Yr.	Relative Levels Winter	Spring	Summer	Fall
National			32	43	48	38	40	0.81	1.06	1.20	0.93
New England (I)			32	36	42	32	36	0.90	1.02	1.16	0.90
Midatlantid (II)			51	57	56	43	52	0.99	1.08	1.10	0.83
Mideast (III)			31	39	39	31	35	0.89	1.13	1.11	0.88
Southeast (IV)			31	33	28	32	31	1.00	1.09	0.89	1.01
Midwest (V)			39	61	70	54	56	0.71	1.15	1.18	0.95
Great Plains (VI)			25	52	45	42	41	0.65	1.23	1.07	1.07
Gulf South (VII)			31	53	53	54	48	0.64	1.14	1.13	1.12
Rocky Mountain (VIII)			15	21	69	25	32	0.46	0.79	1.97	0.81
Pacific Coast (IX)			36	31	31	27	31	1.07	0.97	1.15	0.80
Connecticut	3	4	43	35	39	38	39	1.10	0.90	1.00	0.97
Maine	3	2	27	25	29	26	27	1.00	0.93	1.07	0.96
Massachusetts	2	2	37	52	54	39	46	0.80	1.13	1.17	0.85
New Hampshire	2	5	15	21	22	17	19	0.79	1.11	1.16	0.89
Rhode Island	2	4	35	38	58	28	40	0.88	0.95	1.45	0.70
Vermont	1	8	35	47	48	45	44	0.80	1.07	1.09	1.02
Delaware	1	4	58	75	58	48	60	0.97	1.25	0.97	0.80
Pennsylvania	3	8	43	39	53	37	43	1.00	0.91	1.23	0.86
Kentucky	2	8	37	35	48	36	39	0.95	0.90	1.23	0.92
Maryland	2	4	36	48	43	38	41	0.88	1.17	1.05	0.93
North Carolina	3	2	34	40	30	28	33	1.03	1.21	0.91	0.85
Virginia	3	5	24	39	37	30	32	0.75	1.22	1.16	0.94
West Virginia	2	8	26	35	37	23	31	0.84	1.13	1.19	0.74
Alabama	2	7	31	27	23	36	29	1.07	0.93	0.79	1.24
Florida	2	2	21	43	21	20	26	0.81	1.65	0.81	0.75
Georgia	2	2	45	36	31	41	38	1.18	0.95	0.82	1.08
Mississippi	3	7	26	28	26	29	28	0.93	1.00	0.93	1.04
South Carolina	2	4	34	32	38	32	34	1.00	0.94	1.12	0.94
Illinois	2	4	44	79	57	43	57	0.77	1.39	1.00	0.75
Indiana	2	4	50	60	58	70	60	0.83	1.00	0.97	1.17
Michigan	3	6	30	51	56	42	44	0.68	1.16	1.27	0.95
Ohio	1	6	45	63	149	83	85	0.53	0.74	1.75	0.98
Wisconsin	2	6	27	53	32	32	36	0.75	1.47	0.89	0.89
Iowa	2	4	42	84	44	55	56	0.75	1.50	0.79	0.98
Minnesota	2	6	17	73	90	50	58	0.29	1.26	1.55	0.86
Missouri	2	5	33	41	33	37	36	0.92	1.14	0.92	1.03
Nebraska	3	4	17	28	31	42	29	0.59	0.97	1.07	1.45
North Dakota	3	4	18	33	27	27	26	0.69	1.27	1.04	1.04
Arkansas	2	5	26	60	47	40	43	0.60	1.40	1.09	0.93
Louisiana	1	7	49	53	65	85	63	0.78	0.84	1.03	1.35
New Mexico	2	8	20	41	49	42	38	0.53	1.08	1.29	1.11
Oklahoma	1	4	29	56	51	49	46	0.63	1.22	1.11	1.07
Colorado	3	8	8	23	25	11	17	0.47	1.35	1.47	0.65
Idaho	3	3	15	19	35	29	24	0.63	0.79	1.46	1.21
Montana	3	8	6	11	47	13	19	0.32	0.58	2.47	0.68
Utah	2	3	29	31	170	47	69	0.42	0.45	2.46	0.68
Arizona	2	3	16	23	45	24	27	0.59	0.85	1.67	0.89
Nevada	2	3	22	19	24	10	19	1.16	1.00	1.26	0.53
Oregon	2	9	70	51	25	47	48	1.46	1.06	.52	0.98

TABLE 6. COMPARISON OF GROSS AND NET URBAN RELATIVE SEASONAL PARTICULATE LEVELS

Station	Relative Seasonal Levels			
	W	Sp	Su	F
Charleston, Gross	1.13	1.13	0.64	1.07
Charleston, Net	1.18	1.12	0.55	1.13
Phoenix, Gross	1.33	0.89	0.73	1.03
Phoenix, Net	1.43	0.90	0.61	1.03
Pittsburgh, Gross	1.05	1.13	1.02	0.75
Pittsburgh, Net	1.08	1.20	0.98	0.74
Helena, Gross	0.83	0.79	1.20	1.14
Helena, Net	1.02	0.85	0.81	1.27

TABLE 7. SEASONAL LEVELS OF SUSPENDED PARTICULATES

Nonurban Stations by Topographic Class

Topo. Class	Number of Stations	Mean $\mu g/m^3$.	Relative Seasonal Levels			
			W	Sp	Su	F
Atlantic Coast (2)	5	34	0.96	1.19	0.94	0.90
Gulf Coast (7)	3	40	0.93	0.92	0.92	1.21
Great Lakes (6)	4	56	0.56	1.16	1.37	0.92
Pacific Coast (9)	1	48	1.46	1.06	0.52	0.98
Farmland (4)	11	44	0.83	1.16	1.05	0.98
Forest (5)	4	33	0.77	1.22	1.08	0.95
Mountain (8)	7	33	0.72	1.00	1.42	0.85
Desert (3)	4	35	0.70	0.77	1.71	0.83

( ) numerical code used in Table 4.

Table 8. SEASONAL LEVELS OF BENZENE SOLUBLE ORGANIC MATTER

Urban Stations

Stations	Region	Mean Levels, $\mu g/m^3$					Relative Levels			
		Winter	Spring	Summer	Fall	3-Year	Winter	Spring	Summer	Fall
Hartford, Conn.	I	11.7	8.7	6.1	9.4	9.1	1.29	0.96	0.67	1.03
New Haven, Conn.	I	11.9	6.7	7.4	10.9	9.3	1.28	0.72	0.80	1.17
Boston, Mass.	I	15.3	12.5	9.6	12.6	12.3	1.24	1.02	0.78	1.02
Providence, R. I.	I	14.2	12.2	7.3	14.1	11.9	1.19	1.03	0.61	1.18
Burlington, Vt.	I	3.8	4.0	2.6	2.7	3.3	1.15	1.21	0.79	0.82
Wilmington, Del.	II	19.2	11.4	11.3	11.0	13.3	1.44	0.86	0.85	0.83
New York City, N. Y.	II	18.0	16.0	14.7	12.1	15.3	1.18	1.05	0.96	0.79
Philadelphia, Pa.	II	15.4	9.6	8.3	14.9	12.3	1.25	0.78	0.67	1.21
Pittsburgh, Pa.	II	20.8	17.9	12.3	11.5	15.7	1.32	1.14	0.78	0.73
Baltimore, Md.	III	16.1	13.7	9.2	12.1	12.7	1.27	1.08	0.72	0.95
Charlotte, N. C.	III	26.0	13.2	5.2	14.5	14.9	1.74	0.89	0.35	0.97
Norfolk, Va.	III	17.4	10.4	5.6	8.3	10.3	1.69	1.01	0.54	0.81
Charleston, W. Va.	III	12.0	9.8	6.5	9.7	9.6	1.25	1.02	0.68	1.01
Birmingham, Ala.	IV	26.9	12.9	6.9	14.4	15.6	1.72	0.83	0.44	0.92
Tampa, Fla.	IV	11.6	7.2	6.1	8.0	8.1	1.43	0.89	0.75	0.99
Atlanta, Ga.	IV	14.4	12.3	13.4	11.2	12.9	1.12	0.95	1.04	0.87
Jackson, Miss.	IV	6.4	6.6	6.4	8.6	7.1	0.90	0.93	0.90	1.21
Columbia, S. C.	IV	25.9	13.7	10.1	17.0	16.3	1.59	0.84	0.62	1.04
Nashville, Tenn.	IV	18.6	15.2	9.1	20.5	16.0	1.16	0.95	0.57	1.28
Indianapolis, Ind.	V	19.7	15.4	11.7	17.8	16.3	1.21	0.94	0.72	1.09
Detroit, Mich.	V	14.4	10.8	7.6	11.7	11.1	1.30	0.97	0.68	1.05
Cincinnati, Ohio	V	15.0	8.6	6.8	14.2	11.4	1.32	0.75	0.60	1.25
Youngstown, Ohio	V	15.5	12.6	8.8	17.6	13.8	1.12	0.91	0.64	1.28
Cleveland, Ohio	V	14.2	13.6	11.7	11.3	12.8	1.11	1.06	0.91	0.88
Columbus, Ohio	V	12.9	9.5	8.7	13.8	11.3	1.14	0.84	0.77	1.22
Milwaukee, Wisc.	V	9.6	7.5	6.9	8.8	8.3	1.16	0.90	0.83	1.06
Des Moines, Iowa	VI	13.4	8.8	7.6	8.5	9.6	1.40	0.92	0.79	0.89
Minneapolis, Minn.	VI	8.7	8.4	5.2	7.2	7.4	1.18	1.14	0.70	0.97
Kansas City, Mo.	VI	11.8	10.2	11.7	13.4	11.7	1.01	0.87	1.00	1.15
St. Louis, Mo.	VI	21.3	11.9	10.9	16.3	14.9	1.43	0.80	0.73	1.09
Omaha, Neb.	VI	9.3	6.4	7.5	8.8	8.1	1.15	0.79	0.93	1.09
Bismarck, N. D.	VI	4.2	3.9	3.7	4.5	4.1	1.02	0.95	0.90	1.10
Sioux Falls, S. D.	VI	5.5	5.1	4.1	5.7	5.2	1.06	0.98	0.79	1.10
Little Rock, Ark.	VII	9.6	6.1	5.4	9.6	7.7	1.25	0.79	0.70	1.25
New Orleans, La.	VII	12.6	9.9	7.3	13.7	10.9	1.16	0.91	0.67	1.26
Albuquerque, N. M.	VII	21.3	11.1	11.7	19.9	15.8	1.35	0.70	0.74	1.26
Houston, Texas	VII	11.2	6.1	6.2	10.5	8.6	1.30	0.71	0.72	1.22
San Antonio, Texas	VII	7.0	5.7	4.3	7.5	6.1	1.15	0.93	0.71	1.23
Denver, Colo.	VIII	20.4	8.3	7.9	12.9	12.7	1.61	0.65	0.62	1.02
Boise, Idaho	VIII	13.6	8.3	6.2	14.3	10.5	1.30	0.79	0.59	1.36
Helena, Mont.	VIII	4.3	1.9	2.5	2.6	2.8	1.54	0.68	0.89	0.93
Salt Lake City, Utah	VIII	18.1	6.4	6.6	12.6	10.6	1.71	0.60	0.62	1.19
Cheyenne, Wyo.	VIII	5.1	3.3	3.5	5.0	4.3	1.19	0.77	0.81	1.16
Phoenix, Airz.	IX	30.8	10.9	8.0	19.1	17.4	1.77	0.63	0.46	1.10
Los Angeles, Calif.	IX	35.1	20.0	16.2	29.0	24.7	1.42	0.81	0.66	1.17
San Francisco, Calif.	IX	17.3	6.3	4.6	10.4	9.7	1.78	0.65	0.47	1.07
San Diego, Calif.	IX	18.8	7.1	6.0	12.6	11.2	1.68	0.63	0.54	1.13
Portland, Oregon	IX	14.7	7.1	5.8	15.2	10.8	1.36	0.66	0.54	1.41

Table 8. SEASONAL LEVELS OF BENZENE SOLUBLE ORGANIC MATTER (CONTINUED)

Urban Regional and National

Region	Number	Mean Levels, ug/m^3					Relative Levels			
		Winter	Spring	Summer	Fall	3-Year	Winter	Spring	Summer	Fall
New England	I	11.4	8.8	6.6	9.9	9.2	1.23	0.99	0.73	1.04
Midatlantic	II	18.4	13.7	11.7	12.4	14.2	1.30	0.96	0.82	0.89
Mideast	III	17.9	11.8	6.6	11.2	11.9	1.49	1.00	0.57	0.94
Southeast	IV	17.3	11.3	8.7	11.6	12.7	1.32	0.90	0.72	1.04
Midwest	V	14.5	11.1	8.9	13.6	12.1	1.19	0.91	0.74	1.12
Great Plains	VI	10.6	7.8	7.2	9.2	8.7	1.18	0.92	0.83	1.06
Gulf South	VII	12.3	7.8	7.0	12.2	9.8	1.24	0.81	0.71	1.24
Rocky Mountain	VIII	12.3	5.6	5.3	9.5	8.2	1.47	0.70	0.71	1.13
Pacific Coast	IX	23.3	10.3	8.1	17.3	14.8	1.60	0.68	0.53	1.18
National		15.3	9.8	7.8	11.9	11.3	1.34	0.87	0.71	1.07

DISTRIBUTION OF SAMPLING STATIONS

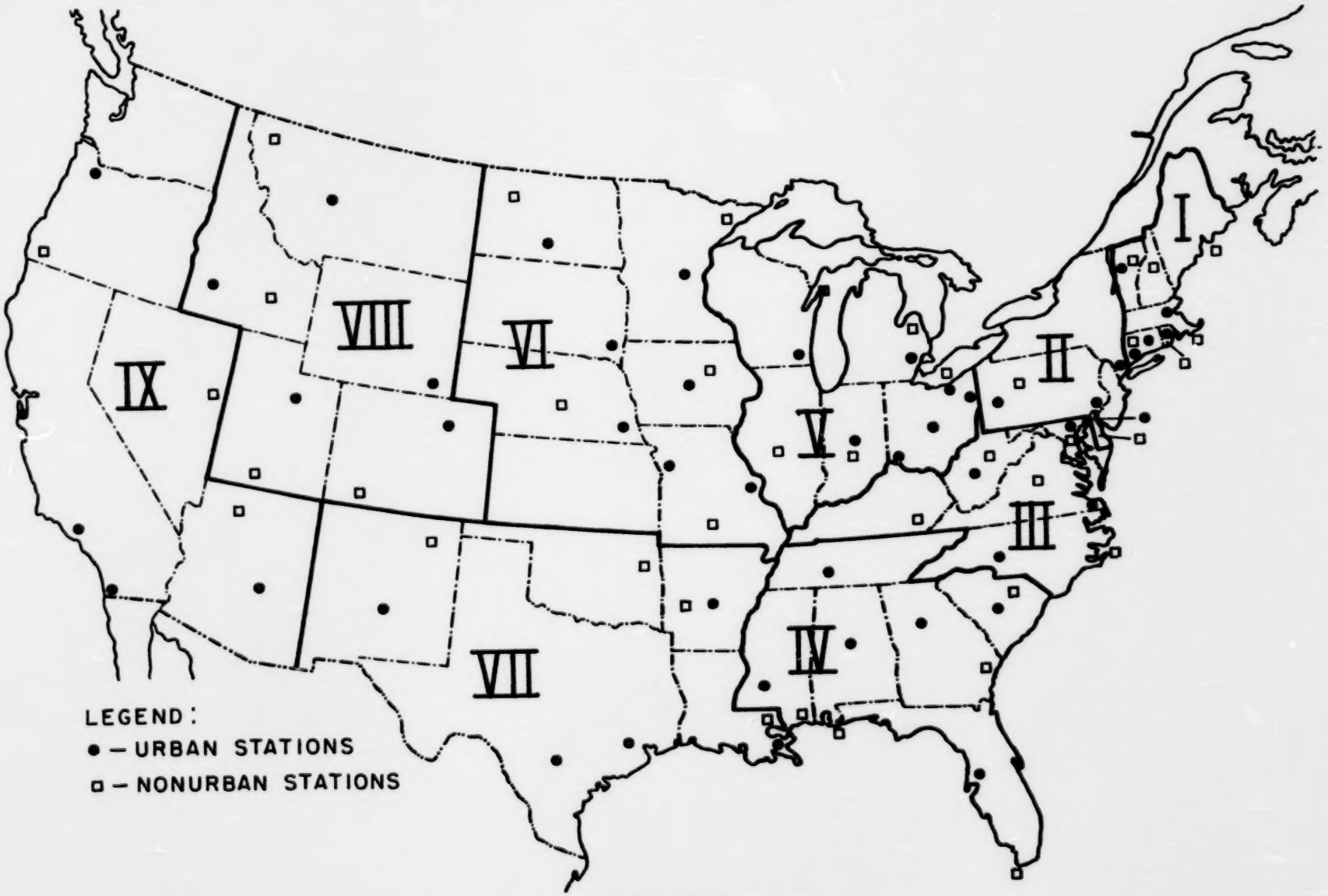
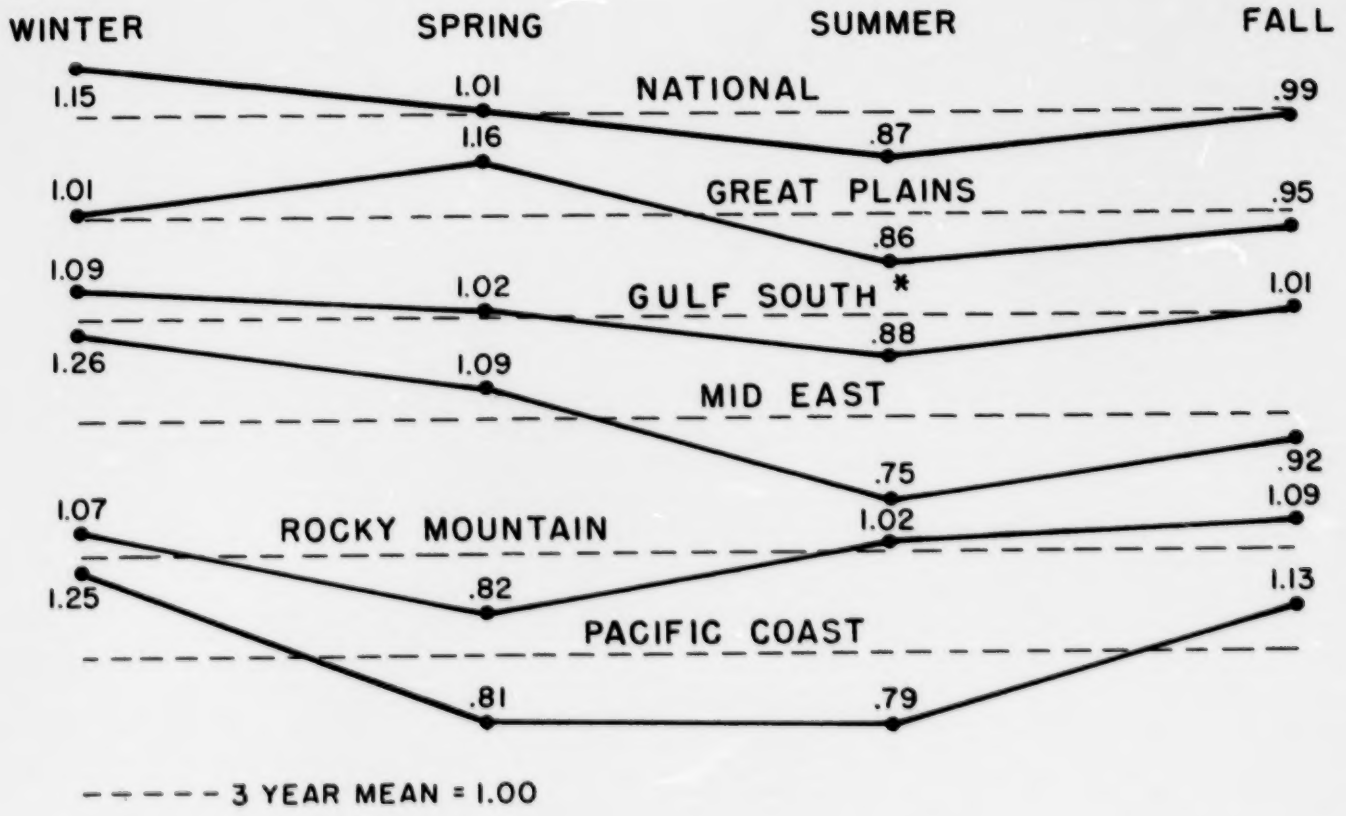


FIGURE 1

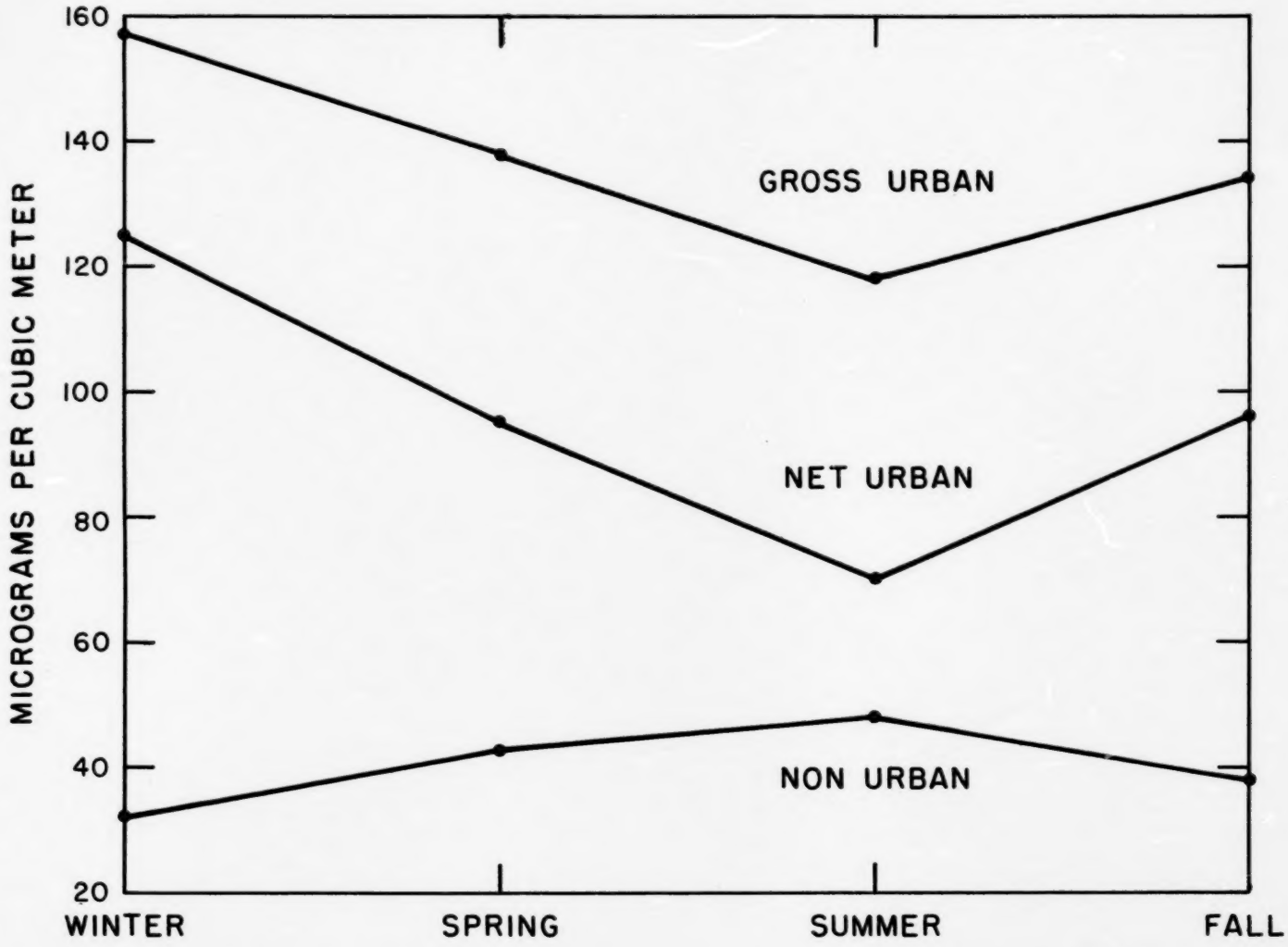


NOTE:

* NEW ENGLAND, SOUTH EAST, MID ATLANTIC, AND MID WEST REGIONS HAVE PATTERNS SIMILAR TO THE GULF SOUTH.

RELATIVE SEASONAL LEVELS OF SUSPENDED PARTICULATES NATIONAL AND REGIONAL

FIGURE 2



RELATIVE SEASONAL LEVELS OF SUSPENDED PARTICULATES
NATIONAL URBAN AND NONURBAN TOTALS

FIGURE 3